

NAPL CONTAMINANT LOCATION WITH HIGH-FREQUENCY CROSSWELL SEISMIC METHODS

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RESEARCH OBJECTIVES

Our objectives are to develop, demonstrate, and evaluate, at appropriate field sites, the utility of high-frequency seismic imaging methods to detect and characterize nonaqueous-phase liquid (NAPL) contamination in groundwater aquifers.

APPROACH

This work is a new application of Berkeley Lab's high-frequency crosswell seismic imaging system. Crosshole seismic data is obtained at sites known to have NAPL contamination to map the distribution of P-wave velocities and amplitudes between boreholes (tomograms). Several approaches are tested to distinguish anomalies arising from the presence of NAPL from those arising from lithological heterogeneities, including: (1) time-lapse measurements before and after remediation, (2) comparison of tomograms from the contaminated location with nearby clean locations, (3) calibration of field data with laboratory measurements on cores from the site with varying amounts of NAPL, and (4) constraint of seismic data with crosswell radar data.

ACCOMPLISHMENTS

We obtained baseline crosswell data (before remediation) at two contaminated sites where remediation is currently in progress. We also measured P-wave transmission on cores from one of the sites, as a function of NAPL/water saturation. At the northeast site of the former DOE Pinellas Plant in Florida, NAPL trichloroethylene (TCE), toluene, methylene chloride, weathered oils, and resins all contaminate the 30 ft deep surficial aquifer. In laboratory tests on core from selected survey boreholes, NAPL TCE and toluene caused significant reductions in P-wave velocity and increases in P-wave attenuation relative to water-saturated conditions. Our crosswell seismic and radar surveys, within and outside of the area identified as having NAPL, reveal continuous sedimentary layers where NAPL could be trapped. Regions of anomalously high P-wave attenuation occur throughout the surveyed region, which may arise from lithology, biogenic gas, NAPL, or a combination of these. At the Paducah Gaseous Diffusion Plant in Kentucky, we collected crosswell seismic data at the location of a historic TCE spill, estimated to be as large as 500,000 gallons,

before beginning a demonstration of six-phase heating remediation. Crosswell data in a NAPL-free area showed generally consistent lithology, with measurable differences, compared to the contaminated site.

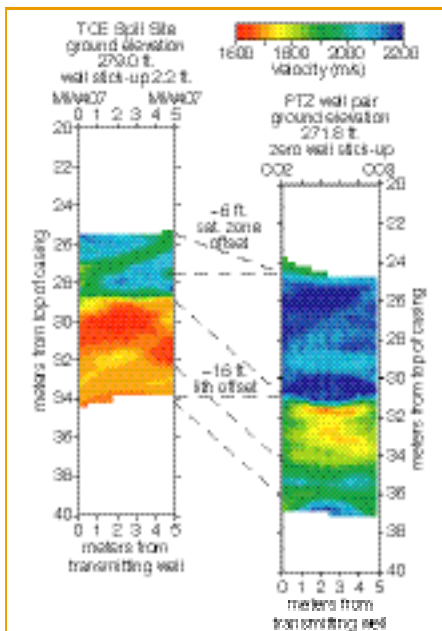


Figure 1. Velocity distributions between survey wells at the Paducah Gaseous Diffusion Plant before the onset of remediation. The tomogram on the left is at the site of the TCE spill. The right hand image is from wells outside the Plant boundary where there is no dense non-aqueous-phase liquid (DNAPL) TCE. The same lithological contrasts occur at each site, and the offsets between the layers are consistent. Changes in these distributions in postremediation surveys will indicate whether the lower velocities at the TCE spill site are caused by DNAPL.

SIGNIFICANCE OF FINDINGS

The contrast in the acoustic velocities of many NAPL contaminants (such as TCE and toluene) in water significantly affect P-wave attributes in natural-aquifer core samples tested in the lab. Possible locations of NAPL areas were identified from comparing P-wave attributes in a nearby uncontaminated zone, but these are uncertain because of the unknown contribution of well-completion and lithology variations. Postremediation surveys will be essential to determine the visibility of NAPL contrasts with water and their signature at the field scale, as well as the efficacy of crosswell seismic imaging for monitoring the remediation of NAPL-contaminated sites.

RELATED PUBLICATIONS

Geller, J.T., J.B. Ajo-Franklin, and E.L. Majer, Effect of immiscible liquid contaminants on P-wave transmission through natural aquifer samples. In Proceedings of the 2003 Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP), Environmental and Engineering Geophysical Society (EEGS), San Antonio, Texas, pp. 1059-1077, April 6-10, 2003; Berkeley Lab Report LBNL-52131.

Ajo-Franklin, J.B., J.T. Geller, E.L. Majer, J.E. Peterson, K.H. Williams, and J.M. Harris, Preliminary characterization of a NAPL-contaminated site using borehole geophysical techniques. In 2003 SAGEEP Proceedings. EEGS, San Antonio, Texas, pp. 202-220, April 6-10, 2003.

ACKNOWLEDGMENTS

This work was funded by the Assistant Secretary of the Office of Environmental Management, Subsurface Contamination Focus Area Program, of the U.S. Department of Energy, under Contract No. DE-AC03-76SF00098.

http://www-esd.lbl.gov/ERT/projects/map_dnapl.html

